

## Fuels, Engines, and Emissions

# Low Temperature Combustion for use as a Diesel Engine Lean NO<sub>x</sub> Trap Regeneration Strategy

## Background

As part of the Department of Energy's strategy to reduce petroleum imports and improve energy security, the FreedomCAR and Vehicle Technologies Program researches technologies that will enable more efficient diesel engines to meet EPA's emissions regulations for nitrogen oxides (NO<sub>x</sub>). Control of NO<sub>x</sub> emissions is critical for enabling clean, fuel-efficient diesel engines. The use of lean NO<sub>x</sub> trap (LNT) catalysts is an active focus for diesel engine NO<sub>x</sub> control. LNT performance must be better understood in order to improve the control of NO<sub>x</sub> emissions.

An LNT catalyst will absorb NO<sub>x</sub> during normal lean operation, typical of diesel engines. These catalysts are very effective, but they must be regenerated as often as every 30 to 90 seconds. Regeneration is accomplished by exposing the LNT to rich exhaust gas which causes the LNT to release the NO<sub>x</sub> and chemically reduce it to harmless nitrogen.

## Technology

Researchers at the Oak Ridge National Laboratory (ORNL) are using advanced instrumentation and measurement methods to develop and characterize different control strategies for maintaining peak catalyst efficiency. Using a modern 1.7-liter Mercedes common-rail, turbocharged diesel engine with

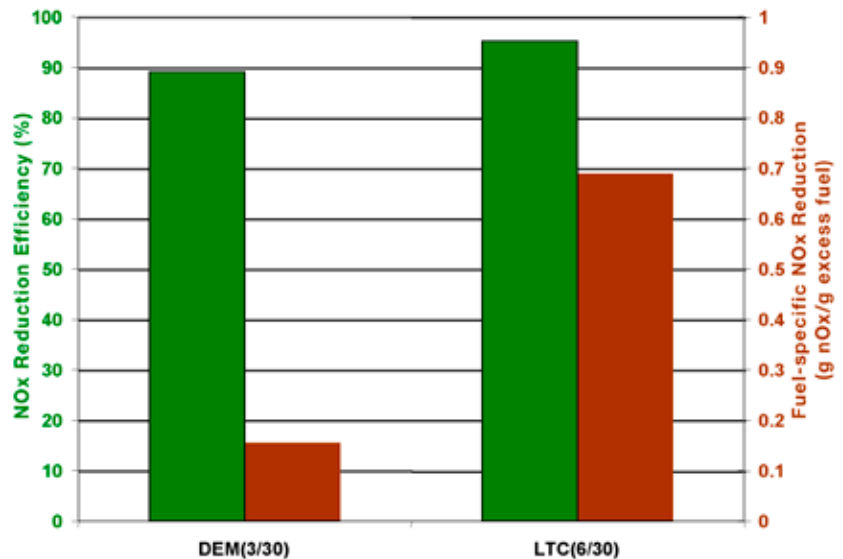


Figure 1. Comparison of strategies for NO<sub>x</sub> reduction and fuel utilization.

## Benefits

- The low fuel consumption for LTC regeneration yields superior fuel specific NO<sub>x</sub> reduction.
- Preliminary data indicates potential for catalyst performance equivalent to other strategies, but with five times more efficient fuel utilization.



full electronic control, ORNL researchers have developed several strategies for LNT regeneration. These strategies typically use throttling, excess fuel, increased EGR, or some combination to induce the rich operation necessary for LNT regeneration.

Under certain operating conditions extreme amounts of EGR (>50%) can induce what is referred to as low temperature combustion (LTC). LTC operation is characterized by simultaneous low NO<sub>x</sub> and low particulate matter (PM), which is highly desirable.

It has been found that with a nominal amount of excess fueling, rich LTC operation can be effectively used for LNT regeneration. For LTC regeneration, 50-55% EGR decreases the air to fuel ratio (AFR) to near stoichiometry, while a small amount of fuel is used to drive the engine rich. Because the required amount of excess fuel is much less than other strategies, LTC carries a greatly reduced fuel penalty.

## Status

LTC regeneration has been shown to achieve comparable NO<sub>x</sub> reduction when compared with other strategies, such as one that delays and extends the main fuel pulse (DEM) to induce rich operation. Comparing the DEM and LTC strategies on a

fuel specific NO<sub>x</sub> reduction basis (that is, grams of NO<sub>x</sub> reduced per gram of excess fuel used) the LTC strategy utilizes fuel some five times more efficiently. The LTC strategy has great promise for contributing to the FCVT Program's low fuel penalty goals.

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